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## **CLAIMS**

- A method of encoding unvoiced segments of speech, comprising:
   partitioning a residual signal frame into a plurality of sub-frames;
   creating a group of sub-frame gains by computing a codebook
   gain for each of the plurality of sub-frames;
- partitioning the group of sub-frame gains into sub-groups of sub-frame gains;

normalizing the sub-groups of sub-frame gains to produce a plurality of normalization factors wherein each of the plurality of normalization factors is associated with one of the normalized sub-groups of sub-frame gains;

converting each of the plurality of normalization factors into an exponential form and quantizing the converted plurality of normalization factors:

quantizing the normalized sub-groups of sub-frame gains to produce a plurality of quantized codebook gains wherein each of the codebook gains is associated with a codebook gain index for one of the plurality of sub-groups;

generating a random noise signal comprising random numbers for each of the plurality of sub-frames;

selecting a pre-determined percentage of the highest-amplitude random numbers of the random noise signal for each of the plurality of subframes;

scaling the selected highest-amplitude random numbers by the quantized codebook gains for each sub-frame to produce a scaled random noise signal;

band-pass filtering and shaping the scaled random noise signal; analyzing the energy of the residue signal frame and the energy of the scaled random signal to produce an energy analysis;

selecting a second filter based on the energy analysis and further shaping the scaled random noise signal with the selected filter; and

generating a second filter selection indicator to identify the selected filter.

- 2. The method of claim 1, wherein the partitioning a residual signal frame into a plurality of sub-frames comprises partitioning a residual signal frame into ten sub-frames.
- 3. The method of claim 1, wherein the partitioning the group of sub-frame gains into sub-groups comprises partitioning a group of ten sub-frame gains into two groups of five sub-frame gains each.
- 4. The method of claim 1, wherein the residual signal frame comprises 160 samples per frame sampled at eight kilohertz per second for 20 milliseconds.
- 5. The method of claim 1, wherein the pre-determined percentage of the highest-amplitude random numbers is twenty-five percent.
- 6. The method of claim 1, wherein two normalization factors are produced for two sub-groups of five sub-frame codebook gains each.
- 7. The method of claim 1, wherein the quantizing the of sub-frame gains is performed using multi-stage vector quantization.
- A method of encoding unvoiced segments of speech, comprising: partitioning a residual signal frame into sub-frames, each sub-frame having a codebook gain associated therewith;

quantizing the gains to produce indices;

scaling a percentage of random noise associated with each subframe by the indices associated with the sub-frame;

performing a first filtering of the scaled random noise;

comparing the filtered noise with the residual signal;

performing a second filtering of the random noise based on the
comparison; and

generating a second filter selection indicator to identify the second filtering performed.

- 9. The method of claim 8, wherein the partitioning a residual signal frame into sub-frames comprises partitioning a residual signal frame into ten sub-frames.
- 10. The method of claim 8, wherein the residual signal frame comprises 160 samples per frame sampled at eight kilohertz per second for 20 milliseconds.
- 11. The method of claim 8, wherein the percentage of random noise is twenty-five percent.
- 12. The method of claim 8, wherein quantizing the gains to produce indices is performed using multi-stage vector quantization.
- 13. A speech coder for encoding unvoiced segments of speech, comprising:

means for partitioning a residual signal frame into a plurality of sub-frames;

- 5 means for creating a group of sub-frame gains by computing a codebook gain for each of the plurality of sub-frames;
  - means for partitioning the group of sub-frame gains into sub-groups of sub-frame gains;
- means for normalizing the sub-groups of sub-frame gains to
  produce a plurality of normalization factors wherein each of the plurality of

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normalization factors is associated with one of the normalized sub-groups of sub-frame gains;

means for converting each of the plurality of normalization factors into an exponential form and quantizing the converted plurality of normalization factors;

means for quantizing the normalized sub-groups of sub-frame gains to produce a plurality of quantized codebook gains wherein each of the codebook gains is associated with a codebook gain index for one of the plurality of sub-groups;

means for generating a random noise signal comprising random numbers for each of the plurality of sub-frames;

means for selecting a pre-determined percentage of the highestamplitude random numbers of the random noise signal for each of the plurality of sub-frames:

means for scaling the selected highest-amplitude random numbers by the quantized codebook gains for each sub-frame to produce a scaled random noise signal;

means for band-pass filtering and shaping the scaled random noise signal;

means for analyzing the energy of the residue signal frame and the energy of the scaled random signal to produce an energy analysis;

means for selecting a second filter based on the energy analysis and further shaping the scaled random noise signal with the selected filter; and means for generating a second filter selection indicator to identify the selected filter.

14. The speech coder of claim 13, wherein the means for partitioning a residual signal frame into a plurality of sub-frames comprises means for partitioning a residual signal frame into ten sub-frames.

- 15. The speech coder of claim 13, wherein the means for partitioning the group of sub-frame gains into sub-groups comprises means for partitioning a group of ten sub-frame gains into two groups of five sub-frame gains each.
- 16. The speech coder of claim 13, wherein the means for selecting a pre-determined percentage of the highest-amplitude random numbers comprises a means for selecting twenty-five percent of the highest-amplitude random numbers.
- 17. The speech coder of claim 13, wherein the means for normalizing the subgroups comprises means for producing two normalization factors for two sub-groups of five sub-frame codebook gains each.
- 18. The speech coder of claim 13, wherein the means for quantizing the sub-frame gains comprises means for performing multi-stage vector quantization.
- 19. A speech coder for encoding unvoiced segments of speech, comprising:

means for partitioning a residual signal frame into sub-frames,

each sub-frame having a codebook gain associated therewith;

quantizing the gains to produce indices;

means for scaling a percentage of random noise associated with each sub-frame by the indices associated with the sub-frame;

means for performing a first filtering of the scaled random noise; means for comparing the filtered noise with the residual signal; means for performing a second filtering of the random noise based on the comparison; and

means for generating a second filter selection indicator to identify the second filtering performed.

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- 20. The speech coder of claim 19, wherein the means for partitioning a residual signal frame into sub-frames comprises means for partitioning a residual signal frame into ten sub-frames.
- 21. The speech coder of claim 19, wherein the means for scaling a percentage of random noise comprises a means for scaling twenty-five percent of the highest-amplitude random noise.
- 22. The speech coder of claim 19, wherein the means for quantizing the gains to produce indices comprises means for multi-stage vector quantization.
- 23. A speech coder for encoding unvoiced segments of speech, comprising:
- a gain computation component configured to partition a residual signal frame into a plurality of sub-frames, create a group of sub-frame gains by computing a codebook gain for each of the plurality of sub-frames, partition the group of sub-frame gains into sub-groups of sub-frame gains, normalize the sub-groups of sub-frame gains to produce a plurality of normalization factors wherein each of the plurality of normalization factors is associated with one of the normalized sub-groups of sub-frame gains, and convert each of the plurality of normalization factors into an exponential form.
- a gain quantizer configured to quantize the converted plurality of normalization factors to produce a quantized normalization factor index, and quantize the normalized sub-groups of sub-frame gains to produce a plurality of quantized codebook gains wherein each of the codebook gains is associated with a codebook gain index for one of the plurality of sub-groups;
- a random number generator configured to generate a random noise signal comprising random numbers for each of the plurality of subframes;

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20 a random number selector configured to select a pre-determined percentage of the highest-amplitude random numbers of the random noise signal for each of the plurality of sub-frames;

a multiplier configured to scale the selected highest-amplitude random numbers by the quantized codebook gains for each sub-frame to produce a scaled random noise signal;

a band-pass filter for eliminating for eliminating low-end and high-end frequencies from the scaled random noise signal;

a first shaping filter for perceptual filtering of the scaled random noise signal;

an unscaled band energy analyzer configured to analyze the energy of the residue signal;

a scaled band energy analyzer configured to analyze the energy of the scaled random signal, and to produce a relational energy analysis of the energy of the residual signal compared to the energy of the scaled random signal;

a second shaping filter configured to select a second filter based on the relational energy analysis, further shape the scaled random noise signal with the selected filter, and generate a second filter selection indicator to identify the selected filter.

- 24. The speech coder of claim 23, wherein the band pass filter and the first shaping filters are fixed filters.
- 25. The speech coder of claim 23, wherein the second shaping filter is configured with two fixed shaping filters.

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- 26. The speech coder of claim 23, wherein the second shaping filter configured to generate a second filter selection indicator to identify the selected filter is further configured to generate a two bit filter selection indicator.
- 27. The speech coder of claim 23, wherein the gain computation component configured to partition a residual signal frame into a plurality of sub-frames is further configured to partition a residual signal frame into ten sub-frames.
- 28. The speech coder of claim 23, wherein the gain computation component configured to partition the group of sub-frame gains into sub-groups is further configured to partition a group of ten sub-frame gains into two groups of five sub-frame gains each.
- 29. The speech coder of claim 23, wherein the random number selector configured to select a pre-determined percentage of the highest-amplitude random numbers if further configured to select twenty-five percent of the highest-amplitude random numbers.
- 30. The speech coder of claim 23, wherein the gain computation component configured to normalize the subgroups is further configured to produce two normalization factors for two sub-groups of five sub-frame codebook gains each.
- 31. The speech coder of claim 23, wherein the gain quantizer is further configured to perform multi-stage vector quantization.
- 32. A speech coder for encoding unvoiced segments of speech, comprising:

- a gain computation component configured to partition a residual signal frame into sub-frames, each sub-frame having a codebook gain associated therewith;
  - a gain quantizer configured to quantize the gains to produce indices:
- a random number selector and multiplier configured to scale a percentage of random noise associated with each sub-frame by the indices associated with the sub-frame;
  - a first perceptual filter configured to perform a first filtering of the scaled random noise;
- a band energy analyzer configured to compare the filtered noise with the residual signal;
  - a second shaping filter configured to perform a second filtering of the random noise based on the comparison, and generate a second filter selection indicator to identify the second filtering performed.
  - 33. The speech coder of claim 32, wherein the gain computation component configured to partition a residual signal frame into sub-frames is further configured to partition a residual signal frame into ten sub-frames.
  - 34. The speech coder of claim 32, wherein the random noise selector and multiplier configured to scale a percentage of random noise is further configured to scale twenty-five percent of the highest-amplitude random noise.
  - 35. The speech coder of claim 32, wherein the gain quantizer configured to quantize the gains to produce indices is further configured to perform multi-stage vector quantization.

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- 36. The speech coder of claim 32, wherein the first perceptual filter configured to perform a first filtering of the scaled random noise is further configured to filter the scaled random noise using a fixed band pass filter and a fixed shaping filter.
- 37. The speech coder of claim 32, wherein the second shaping filter configured to perform a second filtering of the random noise is further configured to have two fixed filters.
- 38. The speech coder of claim 32, wherein the second shaping filter configured to generate a second filter selection indicator is further configured to generate a two bit filter selection indicator.
- 39. A method of decoding unvoiced segments of speech, comprising: recovering a group of quantized gains using received indices for a plurality of sub-frames;
- generating a random noise signal comprising random numbers for each of the plurality of sub-frames;
  - selecting a pre-determined percentage of the highest-amplitude random numbers of the random noise signal for each of the plurality of subframes:
- scaling the selected highest-amplitude random numbers by the
  recovered gains for each sub-frame to produce a scaled random noise signal;
  band-pass filtering and shaping the scaled random noise signal;
  and
  - selecting a second filter based on a received filter selection indicator and further shaping the scaled random noise signal with the selected filter.

- 40. The method of claim 39, further comprising further filtering the scaled random noise.
- 41. The method of claim 39, wherein the plurality of sub-frames comprise partitions of ten sub-frames per frame of encoded unvoiced speech.
- 42. The method of claim 39, wherein the plurality of sub-frames comprise partitions of sub-frame gains partitioned into sub-groups.
- 43. The method of claim 42, wherein the sub-groups comprise partitioning a group of ten sub-frame gains into two groups of five sub-frame gains each.
- 44. The method of claim 41, wherein the frame of encoded unvoiced speech comprises 160 samples per frame sampled at eight kilohertz per second for 20 milliseconds.
- 45. The method of claim 39, wherein the pre-determined percentage of the highest-amplitude random numbers is twenty-five percent.
- 46. The method of claim 43, wherein two normalization factors are recovered for two sub-groups of five sub-frame gains each.
- 47. The method of claim 1, wherein the recovering a group of quantized gains is performed using multi-stage vector quantization.
  - 48. A method of decoding unvoiced segments of speech, comprising:

recovering quantized gains partitioned into sub-frame gains from received indices associated with each sub-frame;

scaling a percentage of random noise associated with each subframe by the indices associated with the sub-frame;

performing a first filtering of the scaled random noise;

performing a second filtering of the random noise determined by a filter selection indicator.

- 49. The method of claim 48, comprising further filtering the scaled random noise.
- 49. The method of claim 48, wherein the sub-frame gains comprise partitions of ten sub-frame gains per frame of encoded unvoiced speech.
- 50. The method of claim 49, wherein the frame of encoded unvoiced speech comprises 160 samples per frame sampled at eight kilohertz per second for 20 milliseconds.
- 51. The method of claim 48, wherein the percentage of random noise is twenty-five percent.
- 52. The method of claim 48, wherein the recovered quantized gains are quantized by multi-stage vector quantization.
  - 53. A decoder for decoding unvoiced segments of speech, comprising:

means for recovering a group of quantized gains using received indices for a plurality of sub-frames;

5 means for generating a random noise signal comprising random numbers for each of the plurality of sub-frames;

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means for selecting a pre-determined percentage of the highestamplitude random numbers of the random noise signal for each of the plurality of sub-frames;

means for scaling the selected highest-amplitude random numbers by the recovered gains for each sub-frame to produce a scaled random noise signal;

means for band-pass filtering and shaping the scaled random noise signal; and

means for selecting a second filter based on a received filter selection indicator and further shaping the scaled random noise signal with the selected filter.

- 54. The speech coder of claim 53, comprising means for further20 filtering the scaled random noise.
  - 55. The speech coder of claim 53, wherein the means for selecting a pre-determined percentage of the highest-amplitude random numbers of the random noise signal further comprises means for selecting twenty five percent of the highest-amplitude random numbers.
  - 56. A decoder for decoding unvoiced segments of speech, comprising:
  - a gain de-quantizer configured to recover a group of quantized gains using received indices for a plurality of sub-frames;
    - a random number generator configured to generate a random noise signal comprising random numbers for each of the plurality of subframes;
- a random number selector configured to select a pre-determined percentage of the highest-amplitude random numbers of the random noise signal for each of the plurality of sub-frames;

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a random number selector and multiplier configured to scale the selected highest-amplitude random numbers by the recovered gains for each sub-frame to produce a scaled random noise signal;

a band-pass filter and first shaping filter to filter and shape the scaled random noise signal; and

a second shaping filter configured to select a second filter based on a received filter selection indicator and further shape the scaled random noise signal with the selected filter.

- 57. The speech coder of claim 56, comprising a post-filter configured to further filter the scaled random noise.
- 58. The speech coder of claim 56, wherein the random number selector configured to select a pre-determined percentage of the highest-amplitude random numbers of the random noise signal is further configured to select twenty five percent of the highest-amplitude random numbers.
- 58. A speech coder for decoding unvoiced segments of speech, comprising:

means for recovering quantized gains partitioned into sub-frame gains from received indices associated with each sub-frame;

means for scaling a percentage of random noise associated with each sub-frame by the indices associated with the sub-frame;

means for performing a first filtering of the scaled random noise; means for performing a second filtering of the random noise determined by a filter selection indicator.

59. The speech coder of claim 58, comprising means for further filtering the scaled random noise.

- 60. The speech coder of claim 58, wherein the means for scaling a percentage of random noise associated with each sub-frame further comprises means for scaling 25% of random noise associated with each sub-frame.
- 61. A speech coder for decoding unvoiced segments of speech, comprising:

a gain de-quantizer configured to recover quantized gains partitioned into sub-frame gains from received indices associated with each sub-frame;

a randon number selector and multiplier configured to scale a percentage of random noise associated with each sub-frame by the indices associated with the sub-frame;

a first shaping filter configured to perform a first perceptual filtering of the scaled random noise;

a second shaping filter configured to perform a second filtering of the random noise determined by a filter selection indicator.

- 62. The speech coder of claim 61, comprising a post-filter for further filtering the scaled random noise.
- 63. The speech coder of claim 61, wherein the random number selector and multiplier configured to scale a percentage of random noise associated with each sub-frame further is configured to scale 25% of random noise associated with each sub-frame.

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